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Statement of

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Committee on Aeronautical and Space Sciences
United States Senate

Mr. Chairman, Members of the Committee:

Thank you for this opportunity to express the views of the National Aeronautics and Space Administration on the challenges and opportunities that face our nation in the field of aeronautics. As you know, part of the genius of the Space Act of 1958 was that it combined in NASA the responsibilities for research programs at the cutting edges of science and technology in both space and aeronautics, rather than separating and diffusing these two powerfully related efforts. A carefully planned and coordinated program of work in the many scientific disciplines and areas of technology in discharge of this combination of responsibilities has made possible the country's rapid build up as a major space power while continuing to advance in aeronautics.

The fundamental building blocks for our successes in the space program have been the technologies, facilities, manpower, industrial know-how, and university relationships that have been operating together since the first World War. These are the interlocking elements that made this nation pre-eminent in air power during World War II and in aeronautical science and commercial and military aviation today. These powerful national resources which continue to produce advances in space and aeronautics are also brought to bear on any problem which arises as our newest equipment goes into use. Their value extends to developing improvements and to overcoming operational problems associated with the early stages of operation where a failure to solve an unforeseen problem can lead to very large losses.

In World War I, World War II, in Korea and now in Viet Nam, we have learned that a strong aeronautical capability is a basic element of total national power. Continued effective advance in aviation is fundamental to our military strength and to the transportation lifelines of the country. An essential factor in reaching and maintaining this position of national power is the effective government - industry - university teamwork that couples the new knowledge acquired through a vast range of research efforts with the cycle of development, test, and production of military and commercial systems. It is this same team that had the vitality and flexibility to respond in the 1950's to the national needs of the development and deployment of missile systems and in the 1960's to the goals and challenges of the space program.

It was a turning point in the history of mankind when the Wright Brothers solved the subtle problem they faced in trying to develop a flying machine: how to achieve dynamic equilibrium through a systems approach, linking all elements in such a way that the man was an integral part of the system and could maneuver it in three dimensions through an integrated system of controls. The underlying concepts of the first airplane are with us today in an unimaginably wide variety of areas, ranging from philosophy to spacecraft. From the early concepts of using a man to control an essentially unstable machine, science and technology have moved us to concepts of the self-correcting, self-monitoring system, whether it be a machine or an institution. Both can be made to respond to very small organized forces intelligently applied at key points that are then magnified into effective action. This ability is perhaps the most important legacy of the Wright Brothers and their first experience in controlled movement in three dimensions.

The concept of the dynamic system organized to assure the most effective interrelation of all its elements and constantly updated by feedback is providing an intellectual framework for dealing with the problems ranging from computer design to city organization. Thoughtful students today believe that our ability as a nation to deal with major problems, armed with the intellectual and technological tools that flow from the efforts of investigation and exploration at the boundaries of human knowledge, are as important elements of true national power in its fullest sense as are the more visible symbols of might reflected in our weapons, factories, or schools.

The power and position of the United States in aeronautics has never been, and is not now, without its challenges. We need not look back very far to find examples of such challenges and of the U.S. response. And it is this ability to respond to surprises that I wish to stress, since it is an ability that can only exist as one part of a total capability that, in turn, is based upon the interlocking results of research, development, and test. In the Second World War, the Japanese Zero fighter, an example of making an advantage of adversity, presented a formidable technological threat to the United States. The strained economy of Japan, responding with ingenuity of design in the absence of critical materials, produced the dangerous high-speed, high-altitude, and highly maneuverable Zero. The U.S. response was a holding operation on the fighting front and a massive build-up of production. Many of us remember the famous Thach Weave, a case where ingenious tactics reduced attrition until we could use our technological ability to design improvements to meet the enemy challenge and to build and man more aircraft than could the enemy. In that same war, Germany put into combat the first jet aircraft and guided missile systems, surprises that had to be met by the application of overwhelming conventional systems. In Korea, the Mig fighters' performance was a surprise. It is true today that the most advanced commercial short takeoff and landing transport airplane is the French Breguet, and that the first supersonic jetliner will be the Concorde, and that the next one may be Russian.

One of the basic jobs of the NASA, and of the NACA before it, is to make sure that the nation has the information, the facilities, and the specialists in many disciplines and technologies available to focus on any high-priority projects, military or civilian, in aeronautics or related fields, and to make sure that a sound, continuing effort creates a wide base of national capability to deal with surprises. This we must do imaginatively and selectively to keep a surprise from becoming a disaster. Perhaps another way of saying the same thing is that it is NASA's job to look ahead to the problems that are going to exist in the future and to do enough work before they arise to show the way toward their solution. And these problems range from basic materials research at one end of the spectrum to flight tests of hypersonic engine systems at the other, from every aspect of crew and passenger safety to social and economic impact of aircraft-induced noise. NASA's work in aeronautical R&D is designed to identify, as well as meet, national needs.

NASA has a broad responsibility to develop, maintain, and use an advanced base of aeronautical research and technology, within its laboratories as well as in the universities and the industry, providing a technical foundation with early experiments and with testing during the later development phase for civil and military air vehicles and associated equipment of all types.

The key products of the NASA aeronautics program are a continuing flow of technical information and a pool of highly skilled experts at the forefront of science and technology in all areas of aeronautics that can apply this information to problems at hand or foreseen. Other government departments, industry, and university personnel therefore have available to them through their association with NASA an understanding of the physical principles underlying new concepts. They have a description, in terms of mathematical analyses, of the principles of new concepts in forms which can be used to solve specific problems. There is evidence, in the form of experimental test results, of the soundness of the physical principles and the analyses so that the new data can be applied in practice with an acceptably low level of technological risk.

The importance of experimental verification and the interplay between experiment and theory in very advanced systems cannot be overemphasized. A physical, or qualitative, understanding of a physical phenomenon, while essential in any technical project, does not in itself provide a basis for the application of new scientific knowledge. New knowledge must be translated into a usable form before the engineer can apply it to the solution of a particular problem. As an example of the interplay between experiment and theory, it is possible to predict with accuracy the amount of lift generated by a wing up to a particular angle, but as the angle exceeds this particular value the effects of air viscosity suddenly dominate and the flow separates from the wing surface. There is no theory to account for flow under these conditions, and thus it is necessary to obtain wind tunnel data before the limitations of any given wing can be fully described.

Research facilities are a necessary part of the process by which the nation obtains data on aerodynamics, structures, propulsion, and electronic components. One of the reasons the National Advisory Committee for Aeronautics (NACA), NASA's predecessor, was established as early as 1915 was in recognition that such facilities were too costly for private industry to procure and support and yet were essential to the advancement of aeronautics. Our research facilities have kept pace with the advances in aviation, enabling continued improvement in the performance, speed, and safety of aircraft. I do not think it is possible to identify an airplane flying today which does not owe much to NACA/NASA research.

Flight testing of new concepts, designs, and systems is fundamental to aeronautics. Laboratory data alone, and theories based on these data, cannot give all the important answers. For example, the effects of motion--pitching, rolling, or yawing--on the airplane and on the man controlling it are not fully predictable from ground-based research. Each time a new aircraft flies, a "moment-of-truth" arrives for the designer as he discovers whether a group of individually satisfactory elements add together to make a satisfactory whole or whether their unexpected interactions result in a major deficiency. Flight research plays the essential role in assuring that all the elements of an aircraft can be integrated into a satisfactory system.

I want to emphasize the point that theory, ground-based research, and flight research are the essential interrelated elements of the aeronautical R&D process. New theories stem from laboratory and flight data; new laboratory facilities are designed and utilized effectively on the basis of both theory and flight data; and a technically and economically sound flight program can only be conducted with the support of theories and laboratory experiments. The pre-eminence of the United States in aviation today could not have been achieved without the ground-based and flight research of the past coupled with the engineering know-how and manufacturing capability of the aerospace industry.

The validity of our aeronautical R&D process--extracting the maximum from today's technology while at the same time developing and testing the technology of the future--is evident in both our military and commercial aircraft. Our very close working relations with the Department of Defense have been mutually beneficial. NASA research on the ground and in flight has, for example, developed the famous "Coke bottle" shape, made possible the successful series of supersonic aircraft such as the F-104, F-106, B-58, and F-4, and demonstrated the feasibility of the variable-sweep wing used on the F-111 and planned for the SST. We are assisting the DoD today in perfecting the operational versions of the F-111. We are, through the use of simulation techniques, helping define specifications for the operating characteristics of the C-5A. The Department of Defense, in turn, has made available to NASA for extended research and flight testing many prototype and production aircraft. The DoD has funded the X-series of experimental aircraft, culminating in the hypersonic X-15, which were used in joint research programs.

Commercial aviation has fully exploited the many advances made possible by the combination of our aeronautics R&D and the completed development of many military aircraft types. The B-47 and B-52 and the KC-135 technologies have been converted into the DC-8 and 707 subsonic jet transports. But as we look forward into the future, we see a growing divergence between the requirements for civil and military aircraft systems. The most modern military aircraft cannot be readily redesigned into commercial systems that can economically meet civil aviation needs. In addition, the increasing complex demands of modern civil transportation have led to changes in the developmental approach for new aircraft.

When unit costs were low and interaction between the elements of the design were small, a manufacturer could afford a substantial element of uncertainty in developing a new airplane, since it was not too difficult or costly to correct deficiencies exposed during flight operations. The correction of such deficiencies has persisted into recent times; for example, some of today's jet transports were retrofitted with larger vertical tails and leading edge flaps after entering commerical service. However, airplanes have now become so complex and embody such great interactions between all the elements of the system that the technological risk of developing a successful new aircraft on the first try is high; moreover, the possibility of easily correcting a first-flight-exposed deficiency is low. Development and unit costs have become so great that deficiences will lead to major escalations in cost and could mean financial disaster for a commercial venture. Economics thus require the designer to take an increasingly conservative approach in applying new and advanced concepts.

An increasing gap is appearing between the advanced technology that research indicates is possible and the technology actually being used in commerce. To assure pre-eminence in aeronautics, advanced technology must continually be incorporated into new designs. To make this economically attractive, new structural, propulsive, or control system concepts must be proven through experimental hardware verification and flight demonstrations to minimize the technical and economic risks of incorporating them in an operational aircraft. With the changing nature of military aviation reducing the number of commercially useful concepts being proven through development, a "civil aircraft technology" must be established at a level of confidence which is acceptable for the investment of private capital.

Working closely with the new Department of Transportation and the FAA, NASA is contributing to the identification of the critical, specialized civil aviation technology requirements and is directing a significant portion of its manpower and facilities resources to the solution of both present and future problems in this area. We have undertaken a major effort in the supersonic transport field, including work on second-generation propulsion, sonic boom phenomena, and aircraft handling qualities. We are working closely with industry and the regulatory agencies on the problems of jet engine noise suppression. We have initiated a large scale experimental engine program directed toward the development of a wholly new "quiet" engine.

Looking into the future, we can identify several areas of special interest that can contribute importantly to national transportation needs. For example, the special capabilities of the helicopter for urban transportation are today offset by problems of vibration, low efficiency, and high operating costs. The jet flap and tilt rotor concept now being investigated hold high promise for early solutions to these problems. For interurban transportation, it appears that commercial STOL transports with operating ranges of some 500 miles that can operate from 1,000 foot runways represent an ideal addition to the national transportation inventory. Efficient high-lift systems for both propeller and jet aircraft have been identified. Similar high-lift techniques, coupled with engines operating at low noise levels, would increase the utility of the standard subsonic jet transport by permitting short field operations in or near cities and by making modern air service practical in many areas now limited by small airports. These are representative examples of the many national needs of commercial aviation, needs that also include navigation and communication systems, air-to-air collision avoidance, safer passenger seating developments, all weather landing and take-off capabilities, and efficient reliable engines with extended operating times between overhauls.

In closing, I would like to underline a major theme that must run through any informed discussion of aeronautics today: the process by which research and development in aeronautics is carried out in the United States has created and constantly replenishes one of our most significant reservoirs of national capability. In the process of meeting the specialized needs of both military and commercial aviation, the total complex of governmental agencies, centers of learning, industrial organizations, and transportation systems is being strengthened by cooperative interaction. Within this complex, NASA has a unique role to play, providing a resource that can be counted upon by each and every element involved in aeronautics. NASA is involved in every phase of the long cycle from theory to operations, providing independent analysis, expert advice, and practical solutions to hard problems. We are proud of our competence and of our flexibility; we are proud of the continuing contributions we make to the full range of aeronautical science and engineering; but we are perhaps the most proud of being effective partners with the universities, the aerospace and transportation industries, and other government agencies in the challenging work of meeting the nation's needs and increasing the nation's strength.